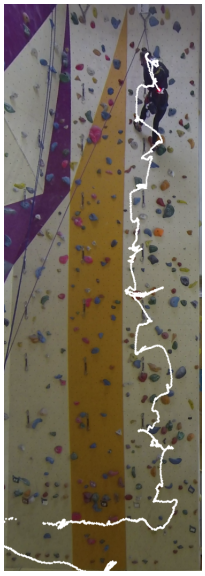
Change-point analysis of circular time series with applications to climbing data

Supervisors: J.-F. Coeurjolly (`Jean-Francois.Coeurjolly@upmf-grenoble.fr`)
Location: Laboratoire Jean Kuntzmann, Grenoble.
Duration: 4 months.
Remuneration: standard traineeship grant (550 euros/month, funded by the ANR Dynamov, PI Ludovic Seifert, Rouen).
Key-words: circular statistics, multiple testing, change-point, `R` software.
Prerequisites: M1 and M2 courses on statistics and probability, knowledge of `R`.

The ANR project DynaMov is a multi-disciplinary project which is concerned with the analysis of human movement to explore behavioural adaptability as a determinant property of expertise. It combines knowledge and methodologies in the human movement sciences, computer sciences and applied mathematics. The primary aim is to investigate the functional role of movement variability in natural contexts where uncertainty and temporal pressure are high, requiring that individuals constantly adapt their behaviours in order to respond to existing dynamical and interactive constraints. Studying the functional role of movement variability involves assessing how adaptive is human behaviour by analysing the balance between movement pattern stability (i.e., persistent behaviour) and flexibility (i.e., variable behaviour) relative to a performance context. Specifically, the project explores how experienced and inexperienced individuals in work and sport, such as firemen and athletes (climbers), adapt their motor behaviours in various performance contexts, i.e., when the environmental properties are stable or in unstable or transitional regions where movement patterns co- exist (technically known as a metastable region). A lot of the data collected in this project correspond to measures of angles along time. In other words, we observe a time series with values on a circle. Such data are very specific and require specific methodologies since for instance the standard mean makes no sense and should be replaced by the geodesic mean or the trigonometric mean.

In a recent paper a standard one-dimensional change-point analysis method to detect changes in the geodesic mean of angular time series from ice-climbers [1]. The method was an extension of the filtered derivative method [2] designed to detect changes in the mean of time series. The main interest of the filtered derivative method is that it is a fast method which can be extended to quite general parameters.

The objective of the internship project is to adapt and extend the findings of this previous research in several methodological and practical directions: (i) extend the methodology to detect changes in the extrinsic mean (also known as a trigonometric mean) and to a trimmed-mean version of this population parameter. (ii) Introduce a control of the false discovery rate or family-wise error rate for the multiple tests used in the two different steps of the filtered derivative method. (iii) The methodologies will be applied to analyse the variability of angular time series corresponding to the neck and hip rolling motion around the vertical axis. Extension of steps (i)-(ii) to understand the coupling of neck and hip rolling should also be considered.



References:

[1 L. Seifert, J.-F. Coeurjolly, R. Hérault, L. Wattebled and K. Davids. Temporal dynamics of inter-limb coordination in ice climbing revealed through change-point analysis of the geodesic mean of circular data. Journal of Applied Statistics, 40(11) 2317–2331, 2013.

[2] P. Bertrand, M. Fhima, and A. Guillin, Off-line detection of multiple change points by the filtered derivative with p-value method, Sequential Anal. 30 (2011), pp. 172–207.

[3] A. Pewsey, M. Neuhäuser and G.D. Ruxton (2013). Circular statistics in R. Oxford University Press.